Introduction to the Splinter on
Mars and the Giant Planets

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based in parts on earlier presentations of
M.Gerin, F.Herpin, and R. Moreno

- The need for celestial calibrators
- Constraints of Herschel (Pointing, Speed, PSF, Visibility)
- Selection criteria
- Potential primary flux calibrators:
  - Uranus: the pros and cons
  - Neptune
  - Mars
- Open questions

Introduction to the Splinter on Mars and the Giant Planets

Why are celestial calibrators essential?

- **Pointing**

- **Photometric Calibration**
  (telescope coupling efficiencies)
- **Properties of the antenna diagrams**:
  Beam widths (beam profiles)
  The exact beam profiles can only be determined in-orbit.
- **Instrument properties:**
  Spectrometers: frequency calibration
  (resolution, line shape, shifts, strengths, ...)
- **Observing modes**

Expected properties of Herschel

- Pointing accuracy

  Absolute 1σ pointing error (APE)

  requirement: 3.7" (results in a flux error of 20% at 158 μm for point source)

  goal: 1.5" (error of 4% at 158 μm)

- Beam widths & Aperture efficiencies

  Expected values:

  500 GHz (600 μm) 45" 72%

  1.9 THz (158 μm) 12" 64%

  How is the remaing power distributed, i.e. how does the PSF couple to the sky ?

- Slewing times

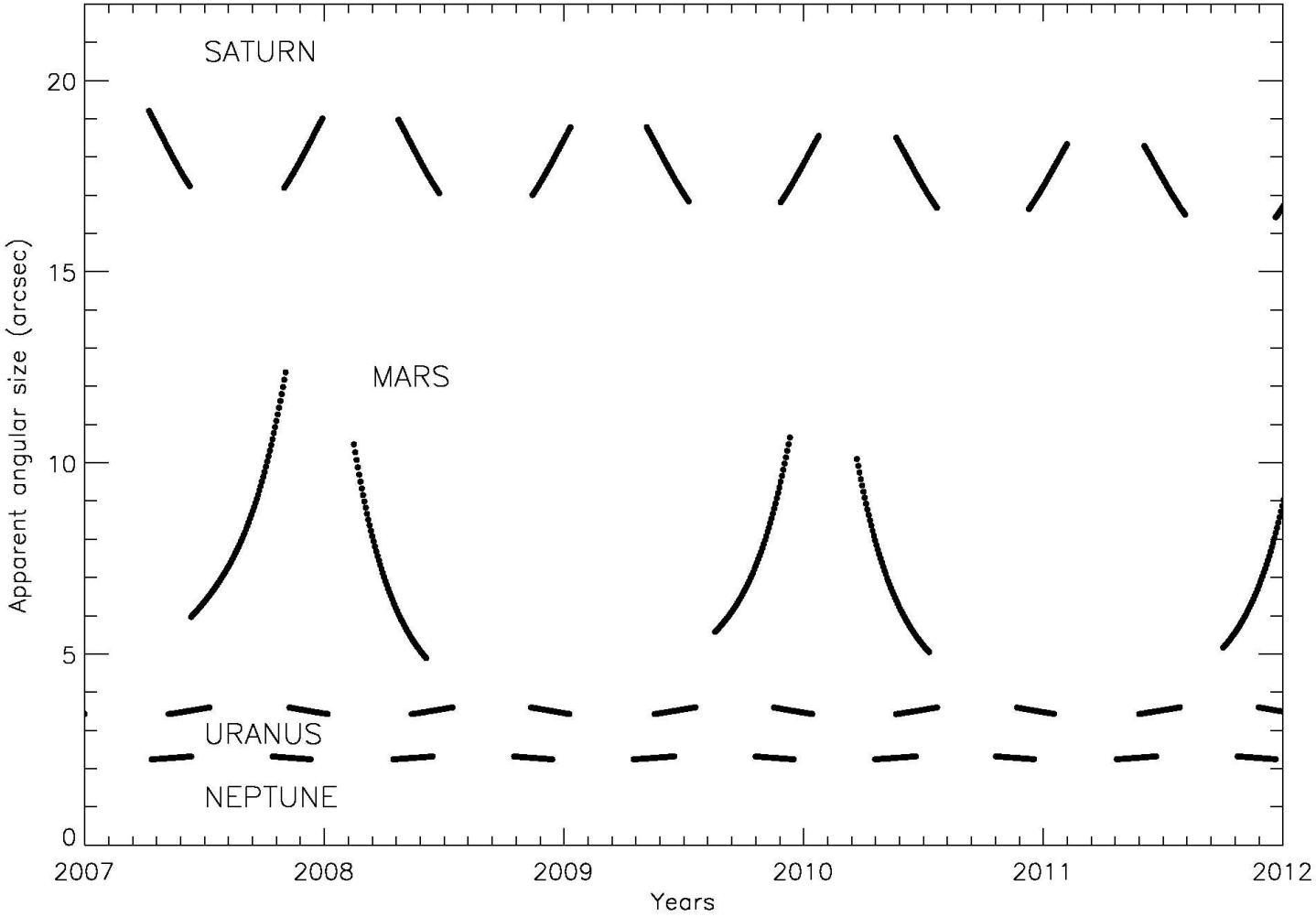
  ~15 min for 90 degrees

  Need for clever observing strategy.

  Need for many calibrators.

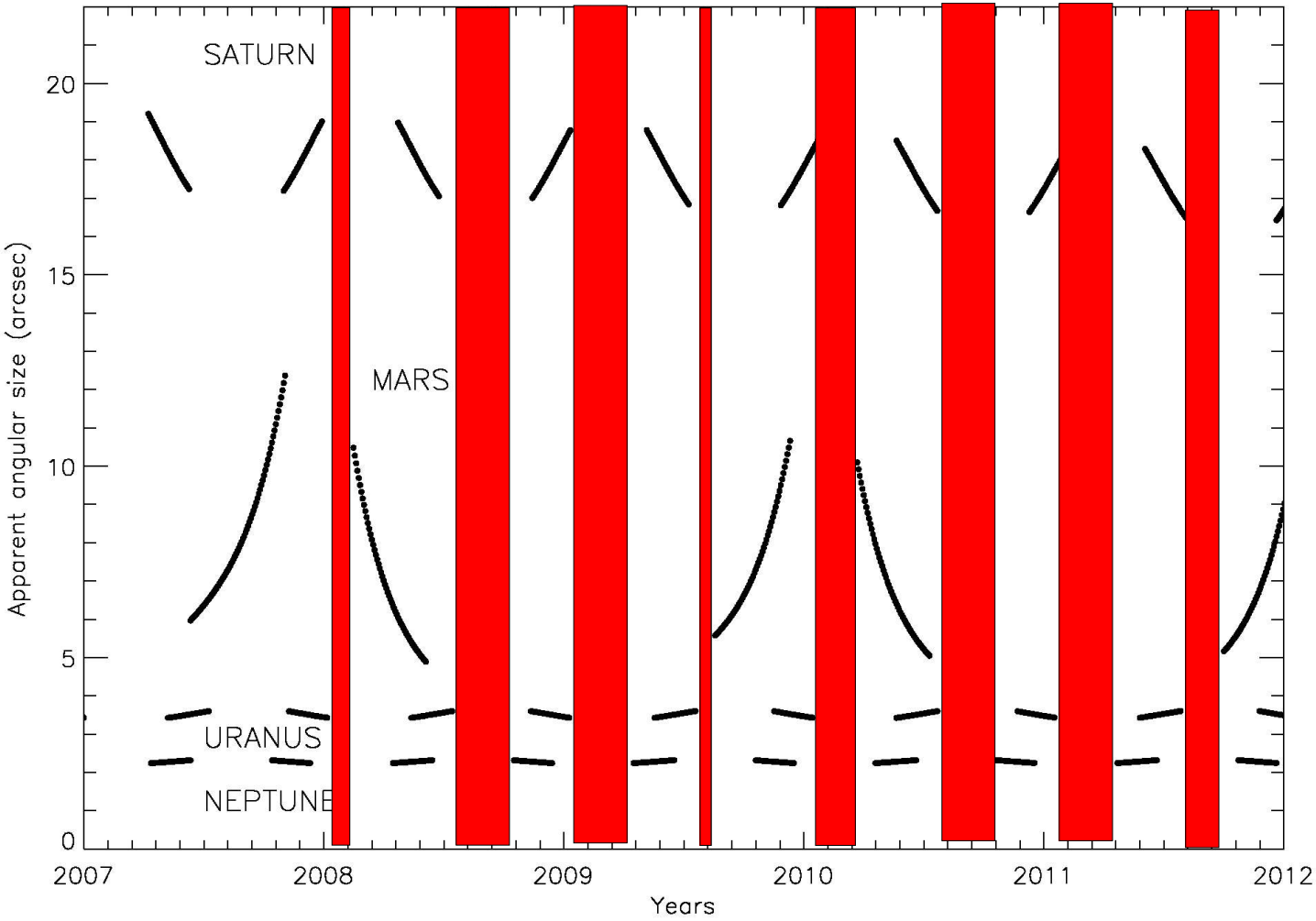
Visibility of Herschel

- Visibility is very restricted !
  One source is not sufficient !!



Visibility of Herschel

- Not even Mars, Uranus, and Neptune are sufficient !!



Requirements on calibration sources

Point-like sources	HIFI (12” beam), SPIRE (18” beam), PACS (6")
Non-variable	HIFI, SPIRE, PACS
Good sky distribution	HIFI, SPIRE, PACS

Photometric calibration:

Well modelled SED	HIFI, SPIRE, PACS (< 10%)
no (few) lines	HIFI, SPIRE, PACS
brightness	HIFI: bright continuum source
	SPIRE: Not too bright (Neptune is at upper end of dynamic range)
	PACS: Uranus & Neptune

Frequency calibration:

Compact sources with rich spectrum	HIFI, SPIRE, PACS
Simple line profiles	
Line fluxes known or predicted	

Different sources for different questions

Body	Date	D ["]	T_B [K]	Flux [Jy]	HIFI
Saturn	15.5.2007	16.9	135	55100	*strong, large*
Mars	1.10.2007	9.8	226	36200	*strong*
Uranus	1.7.2007	3.6	60	662	*weak, point-like*
Ceres	1.1.2008	0.6	196	94	*very weak*

at 1.9 Thz (HIFI Spatial Response Framework document)

Different sources for different questions
Suitability estimate for HIFI:

	Photometry		Spectroscopy
	Aperture Efficiency	Beam Shape	
Saturn	No	Yes (30 dB)	Maybe
Mars	Yes	Yes (30 dB)	Yes (H_2O, CO)
Uranus	Yes	No	Restricted (H_2O)
Ceres	Yes	No!	No!

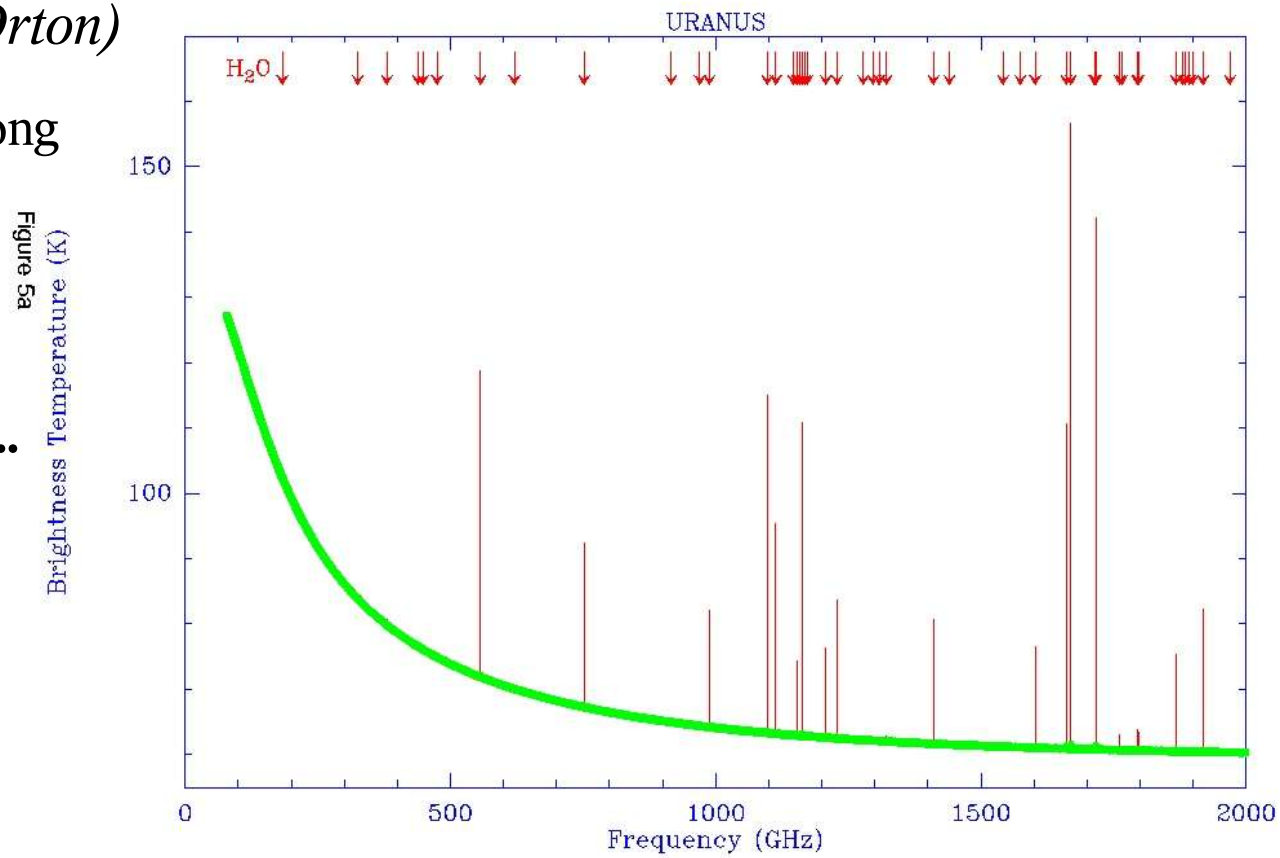
The potential photometric calibrators:

Uranus *(cf. Talk of Glenn Orton)*

Emission is pretty weak/too strong

- Con:
- Stratosphere: H_2O, CO

  Others:
  H_2, He, NH_3, PH_3, H_2S, CH_4 ...



Model of R.Moreno (1998)

- Variability visible in NIR
  Keck AO observations
  (see HST photo)

- Temperature variations of the low atmosphere
  (cm observations of Hofstadter & Butler 2003)
  Talk of Mark Hofstadter

The potential photometric calibrators: Uranus

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- Emission is pretty weak/too strong
- Stratosphere: H_2O, CO
  Others: H_2, He, NH_3, PH_3, H_2S, CH_4

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  (cm observations of Hofstadter & Butler 2003)
  Talk of Mark Hofstadter

The potential photometric calibrators

Uranus:

Pro:

- No surface
  Continuum due to H_2, He, CH_4
- Fast rotation
- Pointlike (3.5")
- ISO/LWS prime flux calibrator, cf. Burgdorf ea 98
- Atmospheric model exists: R.Moreno's thesis (1998)

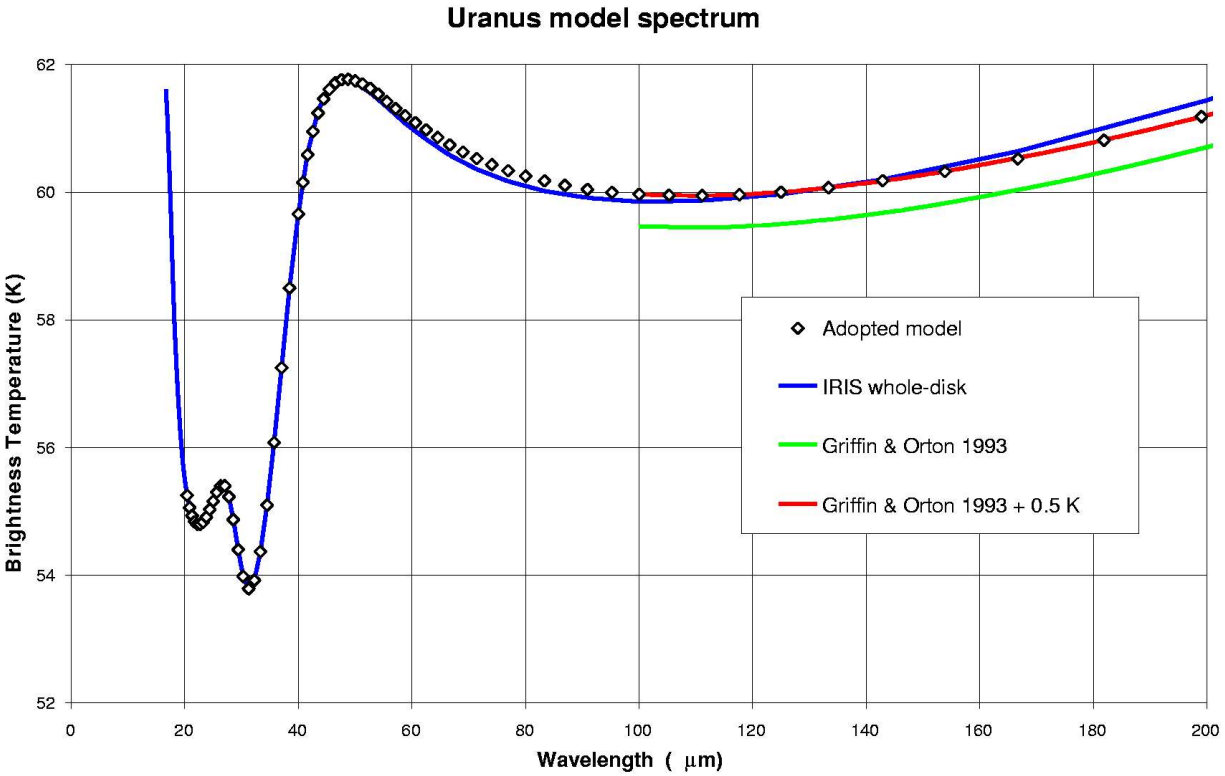


Figure 5.1: *Uranus model used in the LWS photometric calibration.*

- Voyager/IRIS data (5-50 μm): temperature verticle profile well known
- Observations at centimeter (Hofstadter & Butler), millimeter (Gurwell & Butler), submm wavelengths (Serabyn & Pardo et al.), HST & Keck IR (dePater et al., Hammel et al.), Spitzer (G.Orton) *Infos from Bryan*

The potential photometric calibrators

Neptune:

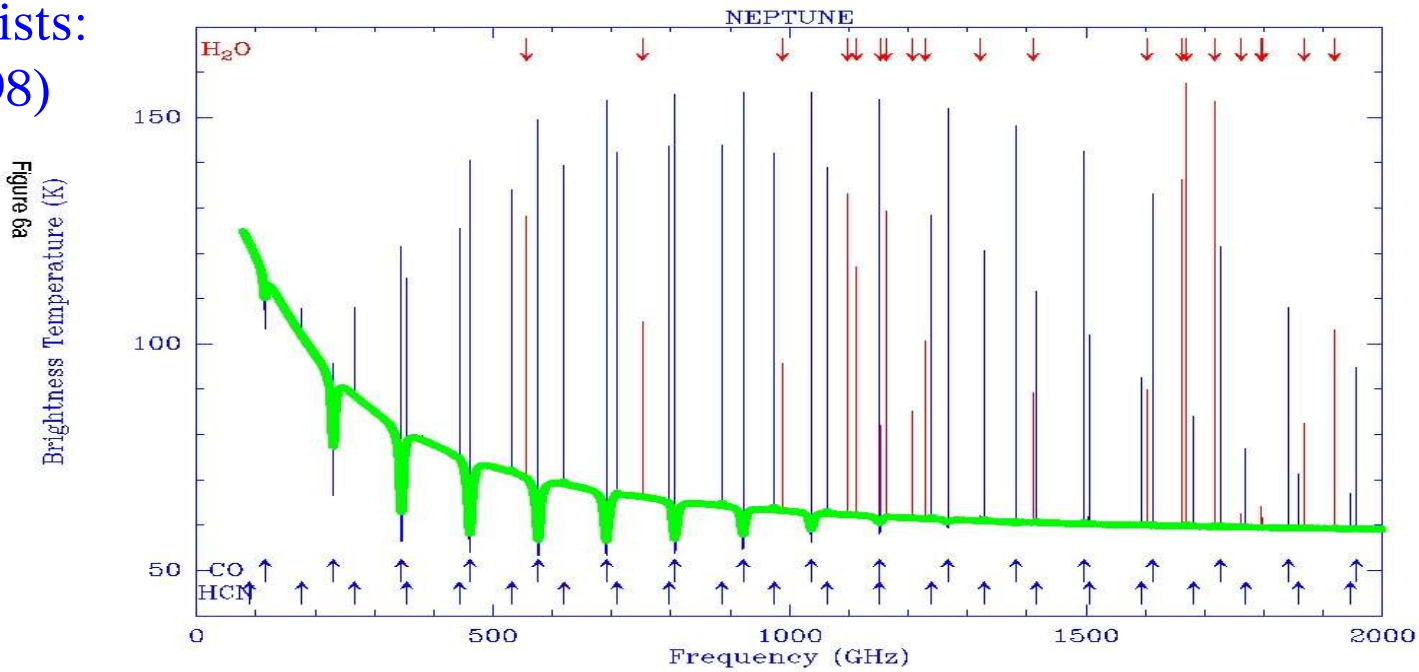
- Too weak (HIFI) / strong (SPIRE, PACS)
- Similar to Uranus

Con:

- Many atmospheric lines

Pro:

- Atmospheric model exists: R.Moreno's thesis (1998)

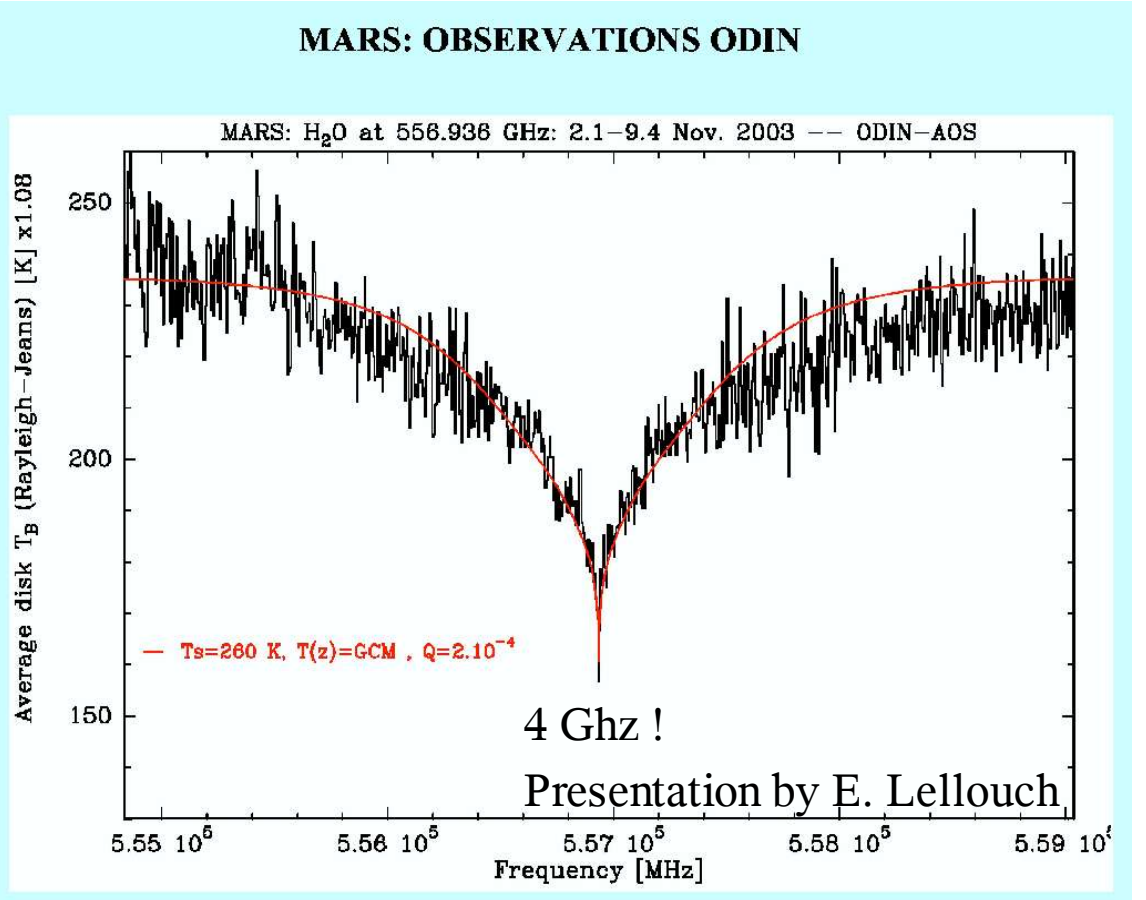


- Frequency calibrator? (HIFI)

The potential photometric calibrators: Mars

Con:

- Teneous but rich atmosphere: H_2O, CO, CO_2, ...
- Water lines are very broad (>1 GHz from SWAS, ODIN)
- Seasonal variations of Water lines (science case!)
- Dust storms (change of atmospheric temperature structure)
- Surface features (dust, ice caps, seasons)



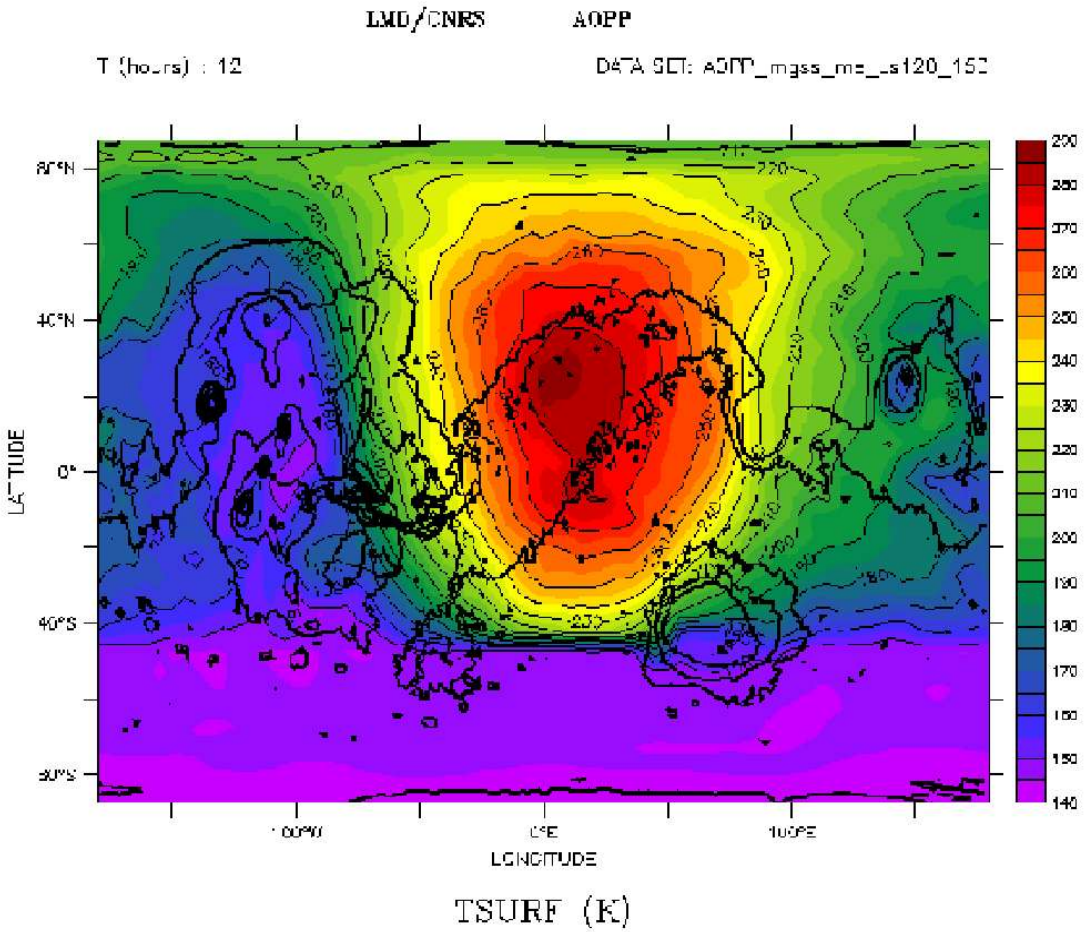
The potential photometric calibrators: Mars

Pro:

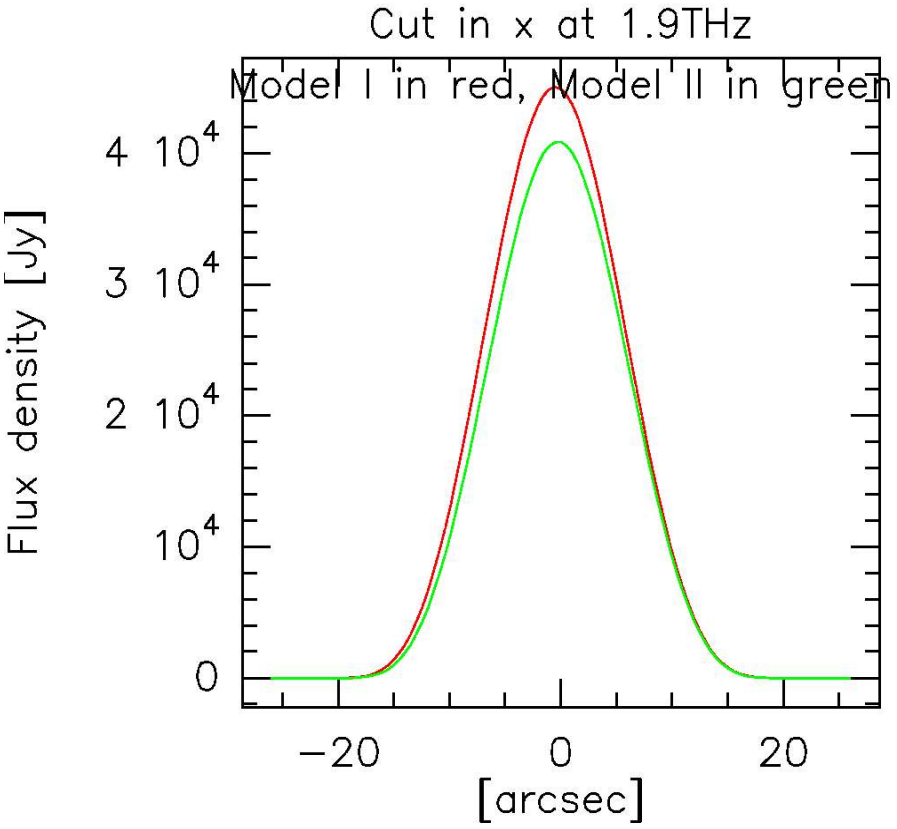
- Bright (T_B~210K) and compact (<13")
- Thermophysical model by Rudy
  (Rudy et al. 1987, Icarus, 71, 159)
- Agreement between model and ISO/LWS
  43 to 196 μm data: **~3%**
  (Sidher, Griffin, et al. 2000, Icarus, 147, 35)
- Other models by T.Encrenaz, E.Lellouch, R.Moreno (LESIA) with F.Forget (LMD); P.Hartogh (MPAE)
- Very well studied object also by in-situ observations (but not in the FIR)
- Often used as the primary calibrator (SWAS, Griffin & Orton, ...)

Talks of Glenn Ortin, Bryan Butler, and Paul Hartogh

The potential photometric calibrators: Mars



Martian surface temperature
(LMD model, Forget et al. 2001)



Simulated Herschel observation at 1.9 THz (Moreno, Kramer) for two extreme models. Peak fluxes agree within +-5%.

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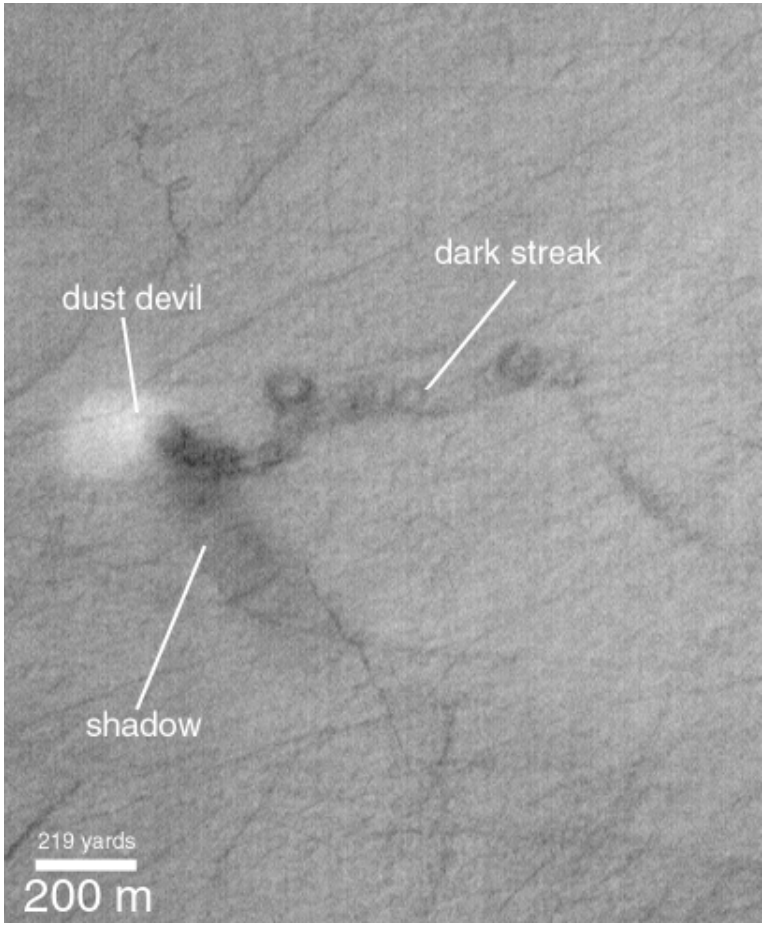
Some Questions:



- Which of the details can be ignored ?
- Mars: can we ignore the atmosphere in the „windows“?
- Giant Planets: can we ignore the lines in the atmospheric windows ?
- Identify incompleteness of models ?
- Preparatory observations:
  - ground-based (FTS/CSO, ...)
  - space (ASTRO-F, Cassini/CIRS (Titan, Saturn, Jupiter), BLAST, SOFIA, ...
  - + Herschel !)